LINE CHARGE CONNECTOR

Statement of Government Interest

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

Cross Reference to Related Application

This is a continuation in part of copending U. S. patent applications entitled "Line Charge Insensitive Munition Warhead" by Felipe Garcia et al., U.S. Patent and Trademark Office Serial No. 08/944049 ~~(NC 78,448)~~, filed 9/2/97 and "Reliable and Effective Line Charge System" by Felipe Garcia et al., U.S. Patent and Trademark Office Serial No. 09/012932 ~~(NC 78,433)~~, filed 1-24-98 and incorporates all references and information thereof by reference herein.

Background of the Invention

This invention relates to deployable munitions. In particular, this invention relates to line charges for clearing mines and obstacles that are made up from explosive segments joined together by connectors which withstand severe deployment forces and position detonation components for each segment to reliably deploy and detonate the line charges.

Anti-personnel obstacles and/or mines have been cleared from narrow passageways or lanes using a number of different explosive devices. Among these devices, however, the above referenced line charge system has proven to be one of the most effective. This line charge has a preassembled series of warheads and a common detonating cord extends through them. A rocket motor pulls the line charge across a designated area, the cord is detonated by a fuze, and the exploding warheads clear the obstacles and mines from a lane that extends the length of the line charge. Notwithstanding the effectiveness of this line charge, the firing teams which deploy it and other obstacle breaching systems have found that sometimes obstacles and/or mines must be cleared from lanes that are longer than the lengths of the preassembled line charges. Heretofore, there has been no effective means to rapidly and reliably connect together portable explosive sections of warheads or other explosives to form differently sized line charges for clearing obstacles and mines over longer distances. Connecting some existing breaching systems together has been a laborious task requiring tools to perform necessary modifications. No connector existed to quickly connect two or more parts of a line charge together in an economical and rapid manner while maintaining structural integrity during deployment and

preserving critical tolerances needed to transfer explosive detonation between parts. Most contemporary line charges are built at the factory as complete units without any means to connect units together in longer line charges.

Thus, in accordance with this inventive concept, a need has been recognized in the state of the art for connectors that interconnect explosive segments of line charges rapidly and reliably in the field to form differently sized line charges for clearing obstacles and mines over different distances.

Summary of the Invention

The invention is directed for providing a connector for segments. A male portion of the connector has coupling elements to connect to strength members of one segment and an axial bore to secure and position one end of detonating cord that extends from the segment. A female portion of the connector has coupling elements to connect to strength members of another segment and an axial bore to secure and position one end of another detonating cord extending from the other segment. A spring clip extends through the female portion and engages part of the male portion which is sized to be inserted in the female portion and engaged by the spring clip. This places the ends of the detonating cords adjacent one another and assures transfer of detonation between them.

An object of the invention is to provide a connector to join explosive segments of line charges for clearing lanes through mines and obstacles.

Another object of the invention is to provide a line charge having connectors joining explosive segments to allow for the modification of the demolition capability of the line charge as needed.

Another object of the invention is to provide rapid and reliable connections of portable explosive segments by a firing team to clear lanes through differently sized areas.

Another object is to provide a connector between explosive segments of a line charge that withstands deployment loads while assuring detonation of the explosive segments.

Another object is to provide means of connecting two or more explosive segments in the field without tools.

Another object of the invention is to provide a connector that assures transfer of detonation between detonation cords and detonation boosters on detonating cords.

Another object of the invention is to provide a connector that axially and linearly aligns explosive components that transfer detonation among explosive segments of a line charge.

Another object is to provide a connector that positively locks to ensure structural integrity of line charges.

Another object of the invention is to provide lightweight, economical, and rapidly coupled connectors between explosive segments of a line charge that maintain structural integrity during deployment and transfer detonation between the detonating cords and boosters of each explosive segment.

These and other objects of the invention will become more readily apparent from the ensuing specification when taken in conjunction with the appended claims.

Brief Description of the Drawings

Figure 1 is a schematic representation of a line charge having a plurality of explosive segments joined by connectors as it is being deployed across obstacles and mines to clear a safe lane.

Figure 2 isometrically depicts a connector having separated male and female portions, and the spring clip removed from the female portion.

Figure 3 is a longitudinal cross-sectional view of the male and female portions taken generally along lines 3-3 in Figure 2 but showing the male and female portions connected together by the spring clip.

Figure 4 is an enlarged cross-sectional view taken along lines 4-4 in Figure 3 showing spring clip on large and small

clip rails in the female portion engaging the groove of the male portion.

Description of the Preferred Embodiment

Referring to Figure 1 of the drawings, line charge 10 is schematically depicted being deployed by an interconnected rocket motor 11. Motor 11 pulls line charge 10 across an area laden with mines and other obstacles that block or interfere with free passage through it. Detonation of the deployed line charge 10 clears a safe and uncluttered passageway.

Line charge 10 includes a plurality of elongate explosive segments 15 coupled together by a plurality of interposed connectors 20. Only three explosive segments 15 are shown coupled together by two connectors 20; it is understood that more or less could be joined by an appropriate number of connectors 20 to clear longer or shorter paths as needed.

Each explosive segment 15 contains a number of serially arranged explosive charges or warheads 15' that are each appropriately connected to elongate flexible strength members 16 and 17 that extend from one end to the other end. Only a few explosive charges or warheads 15' are shown in the leftmost explosive segment 15 in Figure 1 to avoid unnecessary distraction from this invention; it is understood that each explosive segment 15 contains as many such charges 15' as are

needed to successfully complete different missions as they arise. The explosive charges are selected from a wide variety of explosive materials and are appropriately sized and spaced apart to accomplish the task at hand. Strength members 16 and 17 are suitably sized natural or manmade flexible lines or cables, e. g., nylon or metal strands, to provide support during the severe loading encountered as line charge 10 is deployed.

The explosives of each explosive segment 15 are detonated by detonating cord 18 that extends the length of each explosive segment 15. Detonating cord 18 is, preferably, routed through openings in each explosive charge contained in each explosive segment 15. Consequently, when each detonating cord 18 is detonated, all the explosive charges in all explosive segments are exploded virtually simultaneously.

Clearing a lane through an area requires that line charge 10 is emplaced to lie across the area. Then, it is detonated. A proven method of accurately emplacing line charge 10 relies on coupling rocket motor 11 to one end and a drag or an anchoring device 50 to the other end. Anchoring device 50 may be a fixed solid structure at the near side of the area, a drogue chute, or a combination of the two, for example. Rocket motor 11 is aimed to cross the obstructed area. When it is

fired, it accelerates rapidly and pulls line charge 10 along with it. Anchoring device 50 may stop line charge 10 violently from going further. During the launching and stopping phases, connectors 20 hold strength members 16 and 17 of explosive segments 15 together. Initiation of detonation in detonation cord 18' and detonation cord boosters 18' by fuze 19 detonates line charge 10 throughout to break up, blow-out-of-the-way, and/or detonate the obstacles/mines.

Referring to Figure 2, connector 20, fabricated in accordance with this invention, gives the firing team that deploys line charge 10 the capability to change it in the field for different breaching operations. Explosive segments 15 can be carried by the firing team to the area to be breached. All that the team needs to do is merely add or take away explosive segments 15 by connecting the mating portions of male and female portions 25 and 30 of connector 20 via spring clip 40.

Male portion 25 is secured to end portions 16a and 17a of strength members 16 and 17 of explosive segment 15 via a pair of metal or synthetic ring-shaped clamps 26 that may have rounded or flat, strap-like cross-sectional shapes. Clamps 26 may be rigid, but more likely are adjustable with mutually engaging sections tightened and/or otherwise secured to couple end portions 16a and 17a of strength members 16 and 17 to male

portion 25. End portions 16a and 17a are wrapped about clamps 26. The wrapped clamps 26 are slid along outer surface 25a of male portion 25 toward annular rim 27 which radially extends from male portion 25. Clamps 26 clamp end portions 16a and 17a on knurled surfaces 25b on outer surface 25a of male portion 25. In addition, if clamps 26 are positioned next to annular rim 27, clamps 26 also clamp end portions 16a and 17a against annular rim 27. This mechanical cooperation secures male portion 25 to strength members 16 and 17 of one explosive segment 15.

Female portion 30 is secured to end portions 16a' and 17a' of strength members 16' and 17' of explosive segment 15' via a pair of metal or synthetic clamps 31 that may have rounded or flat, strap-like cross-sectional shapes. Clamps 31 may be rigid, but more likely are adjustable with mutually engaging sections. End portions 16a' and 17a' are wrapped about clamps 31. The wrapped clamps 31 are slid along outer surface 30a of female portion 30 toward annular rim 32 which radially extends from female portion 30. Clamps 31 clamp end portions 16a' and 17a' on knurled surfaces 30b on outer surface 30a of female portion 30. In addition, if clamps 31 are positioned next to annular rim 32, clamps 31 also clamp end portions 16a' and 17a' against annular rim 32. This mechanical cooperation secures

female portion 30 to strength members 16' and 17' of another explosive segment 15. No ~~tools~~ tools are needed to connect the male and female portions 25 and 30 together.

If, however, the mating portions of connector 20 have not been previously mounted on ends of strength members 16 and 17, this mounting can be done in the field by the firing team with small hand tools. The firing team can quickly attach male and female portions 25 and 30 to opposite ends of strength members 16 and 17 by merely sliding clamps 26 and 31 off of male and female portions 25 and 30, looping end portions 16a and 17a and 16a' and 17a' of strength members 16 and 17 through rings 26 and 31, respectively. Next, clamps 26 and wrapped ends 16a and 17a are respectively slid along surfaces 25a and 25b to rim 27, and clamps 31 and wrapped ends 16a' and 17a' are slid along surfaces 30a and 30b to rim 32.

Detonating cord 18 is secured into bores 28 and 33 of male and female portions 25 and 30 in the factory using epoxy 28" and 35' in bores 28' and 35. Detonating cord 18 is secured into bores 28 and 33 of male and female portions 25 and 30 in the field by frictionally fitting and engaging detonating cord 18 in bores 28 and ~~35~~ 33, see Figure 3. Bores 28 and 33 are sized to frictionally engage the lateral surfaces of opposite ends 18a and 18b of detonating cords 18 or detonating cord boosters

18' attached to detonating cords 18 of each explosive segment 15. The frictional engagement is such as to hold opposite ends 18a and 18b in close proximity when male and female portions 25 and 30 are coupled together by spring clip 40. This close proximity of ends 18a and 18b is within predetermined tolerance limits required to assure transfer of detonation between adjacent explosive segments. These tolerances are maintained by precisely engaging and locating end portions 18a and 18b of the detonating cords by the critically sized bores 28 and 33 in male and female portions 25 and 30. Consequently, when detonation of the line charge is initiated by detonating the detonating cord in one explosive segment, detonation of all the interconnected explosive segments will occur virtually simultaneously. Note that frictional connection in the field is not as reliable to maintain critical tolerances as the epoxy method performed at the factory.

Details of male and female portions 25 and 30 are shown in Figures 3 and 4. Male and female portions 25 and 30 that have been previously mounted on opposite ends of strength members 16, 17, 16', and 17' of two explosive segments 15 are easily connected together by spring biased legs 40a of spring clips 40. Legs 40a interlock annular groove 29 machined in elongate

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part 25' of male portion 25. Interlocking legs 40a in groove 29 secure male and female portions 25 and 30 together.

Spring clip 40 is releasably mounted in female portion 30 during storage and transit. Spring clip 40 is retained on large clip rail 30' and small clip rail 30" to extend through female portion 30. Large and small clip rails 30' and 30" are formed in female portion 30 when parts of it are machined-away to create openings 36. Legs 40a of clip 40 reach through openings 36 and into bore 34 of female portion 30.

All that is needed to connect male and female portions 25 and 30 together is to insert elongate part 25' of male portion 25 into bore 34 of female portion 30. Tapered front section 25" spreads legs 40a apart as elongate part 25' of male portion 25 is being inserted in bore 34. When legs 40a become radially aligned with portions of annular groove 29 in male portion 25, legs 40a of spring clip 40 snap into annular groove 29 to interlock male portion 25 in female portion 30. This occurs without any tools or unnecessary delay.

Female portion 30 is made of aluminum alloy 6061-T651 a lightweight material that is strong enough to sustain the deployment loads associated with deployment by rocket motor 11. Other suitable lightweight and strong materials could be used, e. g., nylon, space-age plastics, combinations of such

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materials, etc. Female portion 30 is anodized to limit corrosion potential in moist salt environments and to create a low friction sliding surface which eases insertion of elongate part 25' of male portion 25 into bore 34 of female portion 30. Bore 34 is appropriately sized to allow male portion 25 to slide into and fit inside of it and is aligned with the other bores of female portion 30. Female portion 30 has a third bore 35 for passing end portion 18b of detonating cord 18 through it and feeding it to aligned bore 33. Bore 33 is narrower than bore 34 to secure and position end portion 18b of detonation cord 18.

Male portion 25 also is made of aluminum alloy 6061-T651 in order to sustain the deployment loads associated with rocket deployment. Other suitable lightweight and strong materials could be used, e. g., nylon, space-age plastics, combinations of such materials, etc. Male portion 25 is also anodized to limit corrosion potential in moist salt environments and to create a low friction sliding surface to ease insertion of elongate part 25' into bore 34 of female portion 30. Tapered front section 25" of male portion 25 is cone-shaped to facilitate alignment and ease of insertion into bore 34 of female portion 30. As mentioned above, annular groove 29 is provided adjacent tapered front section 25" of male portion 25

to receive spring clip 40 for interlocking and holding male and female portions 25 and 30 together. Bore 28 of male portion 25 is appropriately sized to align and position end portions 18a and 18b of detonating cords 18 in male and female portions 25 and 30 to assure uninterrupted, continuous detonation between adjacent explosive segments 15 of line charge 10. Optionally, to enhance reliability of detonation between adjacent explosive segments 15, detonating boosters 18' may be crimped or otherwise suitably attached to detonating cords 18 in male portion 25 and female portion 30. When detonating boosters 18' are included on detonating cords 18 in male and female portions 25 and 30, ends 18a and 18b will be the ends of detonating boosters 18'.

Male portion 25 has a second bore 28' that may be filled with a suitable bonding agent 28", such as epoxy, to secure detonating cord 18 after it passes through opening 27" of plug 27'. This filling with a suitable bonding agent will occur when male portion 25 is assembled and attached to explosive segment 15 at the factory. When connectors 20 might have to be secured to explosive segments 15 in the field, bonding agent 28" may have to be dispensed with. End portion 18a of detonating cord 18 is additionally secured in male portion 25 by being frictionally engaged in aligned bore 28.

Third bore 35 of female portion 30 may be filled with a suitable bonding agent 35', such as epoxy, to secure detonating cord 18 after it passes through opening 32" of plug 32'. This filling with a suitable bonding agent will occur when female portion 30 is assembled and attached to explosive segment 15 at the factory. When connectors 20 might have to be secured to explosive segments 15 in the field, bonding agent 35' may have to be dispensed with. End portion 18b of detonating cord 18 is additionally secured in female portion 30 by being frictionally engaged in aligned bore 33.

When male portion 25 is fitted in female portion 30 and spring clip 40 engages groove 29, end portions 18a and 18b of detonation cords 18 and detonating boosters 18' of adjacent explosive segments 15 are aligned and sufficiently in contact or close proximity with each other to assure mutual detonation. This proximity between end portions throughout line charge 10 will assure detonation of all explosive segments 15.

The advantages of connector 20 in line charges 10 over previous explosive systems and methods of deployment are numerous. Connector 20 allows for the rapid connection of two explosive segments 15 by the firing team in the field to allow several explosive segments 15 to be carried separately, so that the firing team can carry the total payload in containers

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carried by individual soldiers. Connector 20 provides a light weight, economical, and rapid connection method for connecting together multiple line charge segments without the need for tools. Connector 20 maintains critical tolerances between detonating cord boosters and detonating cords to assure explosive transfer. Strength members of adjacent segments 15 may be attached to the connector in an effective manner. Connector 20 provides axial and linear self alignment of explosive components needed for the transfer of a detonation from one line explosive segment to the next. Connector 20 provides a positive lock thereby ensuring line charge structural integrity. Connector 20 also provides for low friction at the sliding interfaces between male and female portions 25 and 30. Additionally, the knurling provided on the exterior surfaces increases the frictional forces that rings 26 and 31 and rims 27 and 32 exert when attached to strength members 16 of explosive segments 15 of line charge 10.

In the representative embodiment set out herein, only two strength members 16 were shown in each explosive segment 15 only for the purpose of an example. Other arrangements and numbers of strength members could be interconnected to connector 20 in accordance with this invention. In addition, this invention not only is capable of coupling explosive

segments together. These segments might be, for example, segments of an aerially deployed life line containing strong lines or hawsers, segments of electrical power cables, or segments of water or POL supply hoses. When connected according to this invention, the joined segmented structure can reach across barriers or other impasses. The connector of this invention can be modified to provide these capabilities and still be within the scope of this inventive concept.

Connector 20 joining explosive segments 15 of line charge 10 has been described using an exemplary arrangement of components. This arrangement is not to be construed as limiting, but rather is intended for demonstrating this inventive concept. The disclosed components and their arrangements as disclosed herein all contribute to the novel features of this invention. These novel features assure more reliable and effective deployment of multi capable line charges 10 to successfully complete different missions as they arise. It is to be understood that the configuration of the components of connector 20 could be modified to accommodate different applications and still be within the scope of this inventive concept. In addition, different materials could be selected to provide sufficient strength and durability for the task at hand without departing from the scope of this invention. If elastic

limits of the strength members or other materials used in the construction of the original embodiment are exceeded during deployment, then alternative materials may be used to account for increased loading rates.

Therefore, it is to be understood that, having the teachings of this invention in mind, one skilled in the art to which this invention pertains can select other combinations of materials and arrangements thereof and still be within the scope of this invention. Similarly, the capabilities of the invention that were disclosed herein were selected for demonstration of some salient features of this invention. They are not to be construed to limit the scope of this invention.

It should be readily understood that many modifications and variations of the present invention are possible within the purview of the claimed invention. It is to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.